Landslide Prone Areas

Oregon proposed to address this element of the additional management measures for forestry condition through a mix of regulatory and voluntary approaches. While the State has adopted more protective forestry rules to reduce landslide risks to life and property and promoted some voluntary practices to reduce landslide risks through the Oregon Plan for Salmon and Watersheds (The Oregon Plan), Oregon still does not have additional management measures for forestry in place to protect

Since receiving conditional approval on January 13, 1998, Oregon amended the Oregon FPA rules to require the identification of landslide hazard areas in timber harvesting plans and road construction (OAR 629-623-0000 through 629-623-0800). However, under these amendments, shallow, rapidly moving landslide hazards directly related to forest practices are addressed only as they relate to risks for losses of life and property, not for potential water quality impacts. Oregon still allows timber harvest and the construction of forest roads, where alternatives are not available, on high-risk landslide hazard areas as long as it is not deemed a public safety risk.

As noted in the January 13, 1998, findings, timber harvests on unstable, steep terrain can result in increases in landslide rates which contribute to water quality impairments. A number of studies continue to show significant increases in landslide rates after clear-cutting compared to unmanaged forests in the Pacific Northwest. In a study completed in June 1999, "Oregon Department of Forestry, Storm Impacts and Landslides of 1996: Final Report" Robinson et. al indicated that in three out of four areas studied in very steep terrain, both landslide densities and erosion volumes were greater in stands which were clearcut in the previous nine years. Other evidence indicates that timber harvests on unstable, steep terrain can result in increases in landslide rates of approximately 200 to 400 percent. (I need to include a footnote for this document)

For example, in the 2000 study, "Forest Clearing and Regional Landsliding," Montgomery et. al.[1], concluded that landslide rates in Mettman Ridge in the Oregon Coast Range increased after clear cutting at a rate of three to nine times the background rate for the region. The regional analysis from this study found that forest clearing dramatically accelerates shallow landsliding in steep terrain typical of the Pacific Northwest.

Another study by Turner et al. (2010)[2], which Oregon also cited in its July 2013 submission, indicated that at higher rainfall intensities, significantly higher landslide densities occurred on steep slopes compared to lower gradient slopes. The study also found that at higher rainfall intensities, the density of landslides in recently harvested sites was roughly 2-3 times the landslide density in older stands.

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[1] Montgomery, D. R., K. M. Schmidt, H. M. Greenberg & W. E. Dietrich, 2000. Forest clearing and regional landsliding. Geology 28: 311–314.

[2] Turner, T.R., Duke, S.D., Fransen, B.R., Reiter, M.L., Kroll, A.J., Ward, J.W., Bach, J.L., Justice, T. E., and R.E. Bilby. 2010. Landslide densities associated with rainfall, stand age, and topography on forested landscapes, southwestern Washington, USA. Forest Ecology and Management 259 (2010) 2233–2247

One reason landslides on hazard slopes are closely associated with forest clearing is root cohesion. Roots can mechanically reinforce shallow soils in forested landscapes[3]. In a 2001 paper considering the role of root cohesion in landslide susceptibility, Schmidt et. al[4] found that median lateral root cohesion (measured in kilopascals, a measurement of pressure) ranges from 6.8–23.2 kPa in industrial forests with significant understory and deciduous vegetation to 25.6–94.3 kPa in natural forests dominated by coniferous vegetation. In clearcuts, the Schmidt et. al paper found that lateral root cohesion is uniformly less than or equal to 10 kPa, making these areas much more susceptible to landslide.

In a 2004 paper, Sakals and Sidle[5] modeled the effect of different harvest methodologies on root cohesion over time. Their findings suggest that, of the methodologies examined, clear-cutting produces the greatest decline in root cohesion. Further, that root cohesion may continue to decline for 30 years post-harvest. That decline is attributed to the decay of the root systems of the harvested trees, and the fact that young root systems have smaller root volumes and less radial rooting extent. Their findings imply that clear-cutting on hazard slopes could increase the numbers of landslides as well as the probability of larger landslides. A management approach requiring the retention coniferous vegetation on high risk slopes would increase root cohesion and reduce the risk of landslide.

To meet the additional management measure relating to high-risk landslide prone areas, the State must adopt similar harvest and road construction restrictions for all high-risk landslide prone areas with the potential to impact water quality and designated uses, not just those areas where landslides pose risks to life and property. These restrictions could be site specific taking into account factors such as slope, geology and geography or existing or planned land management activities. The State may also want to consider using slope instability screening tools that help identify high-risk landslide to minimize landslide rates and potential impacts to water quality and beneficial uses. .

The State employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide prone areas as a source of large wood. The large wood, which may eventually be deposited into stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery.

While Oregon desires to better capture and evaluate the implementation and effectiveness of voluntary measures, the State has not shown how it intends to do to demonstrate how these voluntary programs ensure water quality and designated uses are protected from landslide impacts, nor has Oregon provided a commitment to exercise those back-up authorities where necessary to protect water quality and designated uses to ensure implementation of this measure. These are required elements if a state chooses to use voluntary programs to support

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[3] Wu, T.H. 1995. Slope stabilization. *In* Slope stabilization and erosion control: A bioengineering approach. *Edited by* R.P.C. Morgan and R.J. Rickson. E & FN Spon, London, pp. 221–264.

[4] Schmidt, K.M., Roering, J.J., Stock, J.D., Dietrich, W.E.,Montgomery, D.R., and Schaub, T. 2001. Root cohesion variability and shallow landslide susceptibility in the Oregon Coast Range. Canadian Geotechnical Journal, **38**: 995–1024.

[5] Sakals, M.E. and R.C. Sidle. 2004. A spatial and temporal model of root cohesion in forest soils. Canadian Journal of Forest Research 34(4): 950-958.

its coastal nonpoint program (see the federal agencies' 1998 Final Administrative Changes guidance).

Action Options & Recommendation

Landslide Prone Areas:

Comment [CJ1]: When developing the issue paper, state upfront the issue to be resolved and the decision which needs to be made by our management. See potential text below.

Comment [AC2]: Ignore this comment for rationale.

~~Issue~~

~~While the State has adopted more protective forestry rules to reduce landslide risks to life and property and promotes some voluntary practices to reduce landslide risks through the Oregon Plan for Salmon and Watersheds (The Oregon Plan), Oregon still does not have additional management measures for forestry in place to protect water quality and designated uses from landslide impacts.~~

~~Should EPA/NOAA use Oregon's failure to adopt additional management measures for forestry to protect high risk landslide areas from negative water quality impacts as a basis for disapproval?~~

~~Background~~

Oregon proposed to address this element of the additional management measures for forestry condition through a mix of regulatory and voluntary approaches. While the State ~~Oregonthe State has~~ has adopted more protective forestry rules to reduce landslide risks to life and property and promoted~~s~~ some voluntary practices to reduce landslide risks through the Oregon Plan for Salmon and Watersheds (The Oregon Plan), Oregon~~it~~ still does not have additional management measures for forestry in place to protect ~~water quality and designated uses from landslide impacts.~~
~~high risk landslide areas to ensure that water quality standards and designated uses are achieved.~~

Comment [CJ3]: When developing the issue paper, consider including an attachment which provides the more detailed information and also includes studies. Also make sure to include the arguments made by the opposing side and how we address them. In this section, be sure to cover:
What are the impacts or significance of the issue?
What are the constraints?
Who is impacted by the issue?
What are the risks of not resolving the issue?

Comment [AC4]: Ignore comment for rationale.

Comment [AC5]: I prefer "the State" here to provide some variety since we just used "Oregon" in the previous sentence.

Comment [AC6]: Stick with this original language as it was written this way on purpose—to match the language we used in the 1998 conditional approval findings.

Since receiving conditional approval on January 13, 1998, Oregon ~~has~~ amended the Oregon FPA rules to require the identification of landslide hazard areas in timber harvesting plans and road construction (OAR 629-623-0000 through 629-623-0800). However, under these amendments, shallow, rapidly moving landslide hazards directly related to forest practices are addressed only as they relate to risks for losses of life and property, not for potential water quality impacts. Oregon still allows timber harvest and the construction of forest roads, where alternatives are not available, on~~f~~ high-risk landslide hazard areas as long as it is not deemed a ~~high-risk sites if the harvest that will not cause a~~ public safety risk ~~and construction of roads on landslide hazard areashigh-risk sites where alternatives are not available~~.

As noted in the January 13, 1998, findings, timber harvests on unstable, steep terrain can result in increases in landslide rates which contribute to water quality impairments. A number of studies continue to show significant increases in landslide rates after clear-cutting compared to unmanaged forests in the Pacific Northwest. In a study completed in June 1999, "Oregon Department of Forestry, Storm Impacts and Landslides of 1996: Final Report" Robinson et. al indicated that in three out of four areas studied in very steep terrain, both landslide densities and erosion volumes were greater in stands which were clearcut in the previous nine years. Other evidence indicates that timber harvests on unstable, steep terrain can result in increases in landslide rates of approximately 200 to 400 percent. (I need to include a footnote for this document)

Comment [CJ7]: You described two studies: 2010 & 2000. Where can the others be found? Also would be helpful to explicitly link the 2010 & 2000 study results to the deficiencies in Oregon's program (i.e. 2000 study indicates Oregon should consider developing MMs to prevent clear cutting in landslide hazard areas or 2010 study indicates Oregon should consider developing MMs needed to prevent harvesting of younger trees in steep slopes with certain amount of rainfall …).

For example, in the 2000 study, "Forest Clearing and Regional Landsliding," Montgomery et. al.[1], concluded that landslide rates in Mettman Ridge in the Oregon Coast Range increased after clear cutting at a rate of three to nine times the background rate for the region. The regional analysis from this study found that forest clearing dramatically accelerates shallow landsliding in steep terrain typical of the Pacific Northwest.

~~In its July 1, 2013, submittal Oregon also cited~~s a Another ~~limited~~ study by Turner et al. (2010)[2], which Oregon also cited in its July 2013 submission, indicated~~ing~~ that at higher rainfall intensities, significantly higher landslide densities occurred on steep slopes compared to lower gradient slopes. The study ~~urner et al. (2010)~~ also found that ~~the effect of stand age was strongest~~ at higher rainfall intensities, ~~concluding that~~ the density of landslides in ~~the most~~ recently harvested sites was~~ere~~ roughly 2-3 times the landslide density ~~larger than~~ in older stands.

One reason landslides on hazard slopes are closely associated with forest clearing is root cohesion. ~~In addition, decades of quantitative measurement indicate that r~~Roots can mechanically reinforce shallow soils in forested landscapes[3]. In a 2001 paper considering the role of root cohesion in landslide susceptibility, Schmidt et. al[4] found that median lateral root cohesion (measured in kilopascals, a measurement of pressure) ranges from 6.8–23.2 kPa in industrial forests with significant understory and deciduous vegetation to 25.6–94.3 kPa in natural forests dominated by coniferous vegetation. In clearcuts, the Schmidt et. al ~~report~~paper found that lateral root cohesion is uniformly less than or equal to 10 kPa, making these areas much more susceptible to landslide.

In a 2004 paper, Sakals and Sidle[5] modeled the effect of different harvest methodologies on root cohesion over time. Their findings suggest that, of the methodologies examined, clear-cutting produces the greatest decline in root cohesion. Further, that root cohesion may continue to decline for 30 years post-harvest. That decline is attributed to the decay of the root systems of the harvested trees, and the fact that young root systems have smaller root volumes and less radial rooting extent. Their findings imply that clear-cutting on hazard slopes could increase the numbers of landslides as well as the probability of larger landslides. A management approach requiring the retention coniferous vegetation on high risk slopes would increase root cohesion and reduce the risk of landslide.

~~Forest canopies also affect the stability of natural slopes. Forest canopies can modify the intensity of precipitation, such that their presence may prevent sliding in some instances. In a~~

Comment [AC8]: Include footnote with full citation.

Comment [KT9]: Inserted

Comment [AC10]: Why is this a "limited" study? Small sample size? Rather than just vaguely stating it was "limited" may be more clear if we clearly acknowledge why it was limited so it doesn't appear like we're hiding anything.

Comment [AC11]: Include footnote with full citation

Comment [KT12]: Inserted

Comment [AC13]: Did it really only "indicate"? That's not a very firm finding. Is it possible to use a stronger verb such as "found" or is "indicate" all that data did?

Comment [CJ14]: May consider explaining or defining "stand age" for the general reader.

Comment [AC15]: So what does this mean about harvesting on steep slopes? Make sure the connection is explicit.

Comment [AC16]: Include full citation in footnote, not just link to report online. Links can break. Also acknowledge who did the study in the rationale.

Comment [KT17]: Inserted

Comment [AC18]: Explain this term. I don't understand what this is and a doubt most of our readers would. Why it is expressed in kPa?

[1] Montgomery, D. R., K. M. Schmidt, H. M. Greenberg & W. E. Dietrich, 2000. Forest clearing and regional landsliding. Geology 28: 311–314.

[2] Turner, T.R., Duke, S.D., Fransen, B.R., Reiter, M.L., Kroll, A.J., Ward, J.W., Bach, J.L., Justice, T. E., and R.E. Bilby. 2010. Landslide densities associated with rainfall, stand age, and topography on forested landscapes, southwestern Washington, USA. Forest Ecology and Management 259 (2010) 2233–2247

[3] Wu, T.H. 1995. Slope stabilization. *In* Slope stabilization and erosion control: A bioengineering approach. *Edited by* R.P.C. Morgan and R.J. Rickson. E & FN Spon, London, pp. 221–264.

[4] Schmidt, K.M., Roering, J.J., Stock, J. D., Dietrich, W.E., Montgomery, D.R., and Schaub, T. 2001. Root cohesion variability and shallow landslide susceptibility in the Oregon Coast Range. Canadian Geotechnical Journal, **38**: 995–1024.

[5] Sakals, M.E. and R.C. Sidle. 2004. A spatial and temporal model of root cohesion in forest soils. Canadian Journal of Forest Research 34(4): 950-958.

~~2003 paper, Keim and Skaugset[6] investigated the effects of forest canopies on slope stability. Their modeling resulted in estimates of slope stability that were generally greater under forest canopy than for the same hillslope without forest canopy.~~

~~[Any additional science we need to include here to bolster our rationale against any of the nay-sayers that don't think there adequate science out there to support the need for add MMs?]~~

To meet the additional management measure relating to high-risk landslide prone areas, the State must adopt similar harvest and road construction restrictions for all high-risk landslide prone areas with the potential to impact water quality and designated uses, not just those areas where landslides pose risks to life and property.~~-~~ These restrictions could be site specific taking into account factors such as slope, geology and geography or existing or planned land management activities. The State may also want to consider using slope instability screening tools that help identify high-risk landslide to minimize landslide rates and potential impacts to water quality and beneficial uses. ~~For example….[see Jayne's CJ7…are there specific BMPs would could recommend?].~~

The State employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide prone areas as a source of large wood. The large wood, which may eventually be deposited into stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery.

W~~However, w~~hile Oregon ~~has professed a~~ desires to better capture and evaluate the implementation and effectiveness of voluntary measures, ~~Oregon~~ the State ~~the state~~ has not shown how it intends to do to demonstrate how these voluntary programs ensure water quality and designated uses are protected ~~so for protection of water quality and designated uses~~ from landslide impacts, nor has Oregon ~~the State~~ provided a commitment to exercise those back-up authorities where necessary to protect water quality and designated uses to ensure implementation of this measure. These are required elements if a state chooses to use voluntary programs to support its coastal nonpoint program (see the federal agencies' 1998 Final Administrative Changes guidance).

Action Options & Recommendation

~~[6] http://onlinelibrary.wiley.com/doi/10.1002/hyp.5121/pdf~~

Comment [AC19]: Include full citation in footnote. Again, make very explicit connection to how this study supports the need for add MMs to protect high-risk landslide hazard areas to protect water quality? How does this contribute to poor water quality?

Comment [KT20]: I added this study initially just to point out that tree canopies also play a role in slope stabilization (it's not just all a function of root cohesion). If you harvest on a hazard slope and expose that slope to additional precip, it is more likely to fail. That said, this rationale is not all that compelling and I'm fine taking it out.

Comment [AC21]: Inserted from Teresa

Comment [CJ22]: May want to briefly list/describe the required elements a voluntary approach and then evaluate which ones Oregon has addressed and has not addressed.

Comment [AC23]: I disagree. We've provided more detailed list in Forestry roads section so don't need to repeat ourselves here.

Comment [CJ24]: When developing the issue paper, include this section in which you explore the various options (approve, disapprove, make no decision) and make a recommendation. Explain why you are not recommending other options. In this section, consider covering:
- What are the options and how do these options address the issue?
- Discuss the pro's and con's and consequences of the various options.
- What are the opposing arguments (whether they've been made or could be made).
- Financial implications?
- Precedent implications?
- Political implications?

Comment [AC25]: Ignore comment for decision rationale.